CLAIMS

1. An image de-ringing filter method, the method comprising:

accepting a plurality of image pixels;

collecting data from a first group of pixels neighboring a test pixel;

in response to the first group data, deciding if the test pixel includes image ringing artifacts;

collecting data from a second group of pixels neighboring the test pixel;

in response to the second group data, generating a filtered value (FV); and,

replacing the test pixel actual value with FV.

2. The method of claim 1 wherein collecting data from a second group of pixels neighboring a test pixel includes performing a mathematical operation on the second group of pixels.

3. The method of claim 1 wherein collecting data from a first group of pixels neighboring a test pixel includes performing a mathematical operation on the first group of pixels.

4. The method of claim 3 wherein collecting data from a first group of pixels neighboring a test pixel further includes comparing the results of the mathematical operation to a threshold.

5. The method of claim 3 wherein performing a mathematical operation on the first group of pixels includes:

defining a matrix; and,

multiplying the first group of pixels by the matrix.

6. The method of claim 5 wherein the matrix is defined such that a zero value is assigned to the position of the test pixel in the matrix.

7. The method of claim 3 wherein performing a mathematical operation on the first group of pixels includes comparing values of pixels on opposite sides of a coordinate axis bisecting the test pixel.

8. The method of claim 7 wherein comparing values of pixels on opposite sides of a coordinate axis bisecting the test pixel includes:

subtracting the values of pixels on a first side of the coordinate axis from pixels on a second side of the coordinate axis, opposite of the first side; and,

comparing the difference to a threshold.

9. The method of claim 8 wherein comparing values of pixels on opposite sides of a coordinate axis bisecting the test pixel includes comparing the values of pixels on opposite sides of a plurality of coordinate axes, oriented in a plurality of directions.

10. The method of claim 7 wherein collecting data from a first group of pixels neighboring a test pixel includes collecting data from a group of 4 pixels neighboring the test pixel.

11. The method of claim 9 wherein comparing values of pixels on opposite sides of a coordinate axis bisecting the test pixel includes:

with respect to a test pixel P(i,j), with i and j indicating row and column indices, respectively, and P(i,j) representing a pixel gray value, using operators H1 and H2 to derive gradient values $g_{H1}(i,j)$ and $g_{H2}(i,j)$, respectively, where

$$H1 = [1\ 0\ -1]; \text{ and,}$$

$$H2=\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$$

calculating $S(i,j) = (|g_{H1}(i,j)| + |g_{H2}(i,j)| + 1) >> 1$;

where >> x represents a binary value right-shift of x;

wherein deciding if the test pixel includes image ringing artifacts includes deciding that P(i,j) includes ringing artifacts, if S(i,j) < threshold.

12. The method of claim 7 further comprising:

selecting a fixed threshold value.

13. The method of claim 1 further comprising:

decoding compressed image information; and,

wherein accepting a plurality of image pixels includes accepting the decoded image information.

14. The method of claim 1 wherein collecting data from a second group of pixels neighboring the test pixel includes adding the test pixel to the second group of pixels.

15. The method of claim 1 wherein collecting data from a second group of pixels neighboring the test pixel includes collecting data from 8 pixels neighboring the test pixel.

16. The method of claim 11 wherein comparing values of pixels on opposite sides of a coordinate axis bisecting the test pixel additional includes:

in response to comparing S(i,j) to the threshold, generating a map value M(i,j) for P(i,j), where:

$$M(i,j) = 1, \text{ if } S(i,j) \geq \text{threshold; and,}$$

$$M(i,j) = 0, \text{ if } S(i,j) < \text{threshold; and,}$$

wherein generating FV includes using pixels from the second group to calculate FV, if they are equal to a first map value.

17. The method of claim 16 wherein generating FV includes the first map value being equal to 0.

18. The method of claim 16 wherein generating FV includes the first map value not being equal to 1.

19. The method of claim 16 wherein generating FV includes selecting pixels from the second group to calculate FV, if they are equal to the first map value.

20. The method of claim 19 wherein generating FV includes randomly selecting pixels from the second group to calculate FV, if they are equal to the first map value.

21. The method of claim 20 wherein accepting a plurality of image pixels includes accepting a plurality of image pixel sets, in a plurality of frames;

wherein generating FV includes:

randomly selecting pixels in a first collection of pixel positions with respect to the test pixel;

using pixels in the first collection to calculate FV for each test pixel in every image pixel set, in every frame.

22. The method of claim 20 wherein accepting a plurality of image pixels includes accepting a plurality of image pixel sets, in a plurality of frames;

wherein generating FV includes:

randomly selecting a first collection of pixel positions with respect to the test pixel in a first image pixel set in a current frame;

using pixels in the first collection to calculate FV for each test pixel in every image pixel set in the current frame;

randomly reselecting a second collection of pixel positions in an image pixel set in a frame subsequent to the current frame; and,

using pixels in the second collection to calculate FV for each test pixel in every image pixel set in the subsequent frame.

23. The method of claim 19 wherein selecting pixels from the second group to calculate FV, if they are equal to the first map value, includes selecting a predetermined collection of pixel positions with respect to the test pixel.

24. The method of claim 23 wherein accepting a plurality of image pixels includes accepting a plurality of image pixel sets in a plurality of frames;

wherein generating FV includes selecting the pixels in a predetermined first collection of pixel positions to calculate FV for each test pixel in every image pixel set, in every frame.

25. The method of claim 23 wherein accepting a plurality of image pixels includes accepting a plurality of image pixel sets in a plurality of frames;

wherein generating FV includes:

selecting the pixels in a predetermined first collection of pixel positions to calculate FV for each test pixel in every image pixel set in a current frame; and,

selecting the pixels in a predetermined second collection of pixel positions to calculate FV for each test pixel in every image pixel set in a frame subsequent to the current frame.

26. The method of claim 23 wherein generating FV includes:

selecting the pixels in a predetermined first collection of pixel positions to calculate FV for each test pixel in a first image pixel set; and,

selecting the pixels in a predetermined second collection of pixel positions to calculate FV for each test pixel in a second image pixel set.

27. The method of claim 16 wherein using pixels from the second group to calculate FV, if they are equal to a first map value, includes:

selectively weighting second group pixel values;

summing the weighted values; and,

averaging.

28. The method of claim 27 wherein collecting data from a second group of pixels neighboring the test pixel includes adding the test pixel to the second group of pixels.

29. The method of claim 27 wherein selectively weighting second group pixel values includes weighting in response to number of pixels in the second group.

30. The method of claim 16 wherein generating FV includes:

calculating nV = sum of second group pixel values for pixels having a map value of 0;

calculating nE = total number of pixels in the second group with a map value of 0;

if nE = 1, then FV = (nV + P(i,j) +1) >> 1;

if nE < 4, then

$nV = nV + (4 - nE)*P(i,j)$; and,

$FV = (nV + 2) >> 2$;

if nE < 8, then

$nV = nV + (8 - nE)*P(i,j)$; and,

$FV = (nV + 4) >> 3$;

if nE = 8, then

$nV = nV - P(i + 1, j +1) +P(i,j)$; and,

$FV = (nV + 4) >> 3$.

31. The method of claim 16 wherein generating FV includes:

calculating nV = sum of second group pixel values for pixels having a map value of 0;

calculating nE = total number pixels in the second group with a map value of 0;

if $nE = 1$, then $FV = (nV + P(i,j) + 1) >> 1$;

if $nE < 4$, then

$nV = nV + (4 - nE) * P(i,j)$; and,

$FV = (nV) >> 2$;

if $nE < 8$, then

$nV = nV + (8 - nE) * P(i,j)$; and,

$FV = (nV) >> 3$;

if $nE = 8$, then

$nV = nV - P(i + 1, j + 1) + P(i,j)$; and,

$FV = (nV) >> 3$.

32. The method of claim 16 wherein generating a FV in response to the second group data includes:

loading a lookup table (LUT) with the pre-calculated values; and,

accessing the LUT.

33. The method of claim 32 generating a FV includes:

calculating nE = the total number of pixels in the second group with the first map value; and,

using nE to access the LUT.

33. The method of claim 32 loading a LUT with the pre-calculated values includes loading a value for each nE indicating the number of times the test pixel P(i,j) is added.

34. The method of claim 32 loading a LUT with the pre-calculated values includes loading a value for each nE indicating the number of times the result is right shifted.

35. The method of claim 32 loading a LUT with the pre-calculated values includes loading a value for each nE indicating if a pixel value from second group of pixels is subtracted.

36. An image de-ringing filter method, the method comprising:

accepting a plurality of image pixels;

performing a mathematical operation on a first group of pixels neighboring a test pixel;

in response to the first group operation, deciding if the test pixel includes image ringing artifacts;

performing a mathematical operation on a second group of pixels neighboring the test pixel;

in response to the second group operation, generating a filtered value (FV); and,

replacing the test pixel actual value with FV.

37. The method of claim 36 wherein performing a mathematical operation on the first group of pixels includes:

defining a matrix; and,

multiplying the first group of pixels by the matrix.

38. The method of claim 36 wherein performing a mathematical operation on the first group of pixels includes comparing values of pixels on opposite sides of a coordinate axis bisecting the test pixel.

39. The method of claim 36 generating a FV in response to the second group operation includes:

generating a map value for each pixel in the second group; and,

using pixels from the second group to calculate FV, if they are equal to a first map value.

40. An image de-ringing filter system, the system comprising:

a decision unit having an input to accept a plurality of image pixels, the decision unit collecting data from a first group of pixels neighboring a test pixel and, in response to the first group data, supplying a decision at an output as to whether the test pixel includes image ringing artifacts; and,

a filter having an input to accept the plurality of image pixels and an input to accept the decision, the filter collecting data from a second group of pixels neighboring the test pixel and, in response to the second group data, generating a filtered value (FV) and supplying the FV at an output as a replacement to the test pixel actual value.

41. The system of claim 40 wherein the filter performs a mathematical operation on the second group of pixels.

42. The system of claim 40 wherein the decision unit performs a mathematical operation on the first group of pixels.

43. The system of claim 42 wherein the decision unit compares the results of the mathematical operation to a threshold.

44. The system of claim 42 wherein the decision unit defines a matrix and multiplies the first group of pixels by the matrix.

45. The system of claim 44 wherein the decision unit defines a matrix such that a zero value is assigned to the position of the test pixel in the matrix.

46. The system of claim 42 wherein the decision unit compares values of pixels on opposite sides of a coordinate axis bisecting the test pixel.

47. The system of claim 46 wherein the decision unit subtracts the values of pixels on a first side of the coordinate axis from pixels on a second side of the coordinate axis, opposite of the first side, and compares the difference to a threshold.

48. The system of claim 47 wherein the decision unit compares the values of pixels on opposite sides of a plurality of coordinate axes, oriented in a plurality of directions.

49. The system of claim 46 wherein the decision unit collects data from a group of 4 pixels neighboring the test pixel.

50. The system of claim 48 wherein the decision unit:

with respect to a test pixel P(i,j), with i and j indicating row and column indices, respectively, and P(i,j) represents a pixel gray value, uses operators H1 and H2 to derive gradient values $g_{H1}(i,j)$ and $g_{H2}(i,j)$, respectively, where

$$H1 = [1\ 0\ -1]; \text{ and,}$$

$$H2=\begin{bmatrix} 1 \\ 0 \\ -1 \end{bmatrix}$$

calculates $S(i,j) = (|g_{H1}(i,j)| + |g_{H2}(i,j)| + 1) >> 1$;

where >> x represents a binary value right-shift of x; and,

decides that P(i,j) is a ringing artifact, if S(i,j) < threshold.

51. The system of claim 40 further comprising:

a decoder having a connection to accepted encoded video information and an output to supply the plurality of image pixels to the decision unit, and to the filter, as decoded image information.

52. The system of claim 40 wherein the filter adds the test pixel to the second group of pixels.

53. The system of claim 40 wherein the filter collects data from 8 pixels neighboring the test pixel.

54. The system of claim 50 wherein the decision unit:

in response to comparing S(i,j) to the threshold, generates a map value M(i,j) for P(i,j), where:

$$M(i,j) = 1, \text{ if } S(i,j) \geq \text{threshold; and,}$$

$$M(i,j) = 0, \text{ if } S(i,j) < \text{threshold;}$$

wherein the filter generates a map value for each pixel in the second group and uses pixels from the second group to calculate FV, if they are equal to a first map value.

55. The system of claim 54 wherein the filter uses a first map value equal to 0.

56. The system of claim 54 wherein the filter uses a first map value not equal to 1.

57. The system of claim 54 wherein the filter selects pixels from the second group to calculate FV, if they are equal to the first map value.

58. The system of claim 57 wherein the filter randomly selects pixels from the second group to calculate FV, if they are equal to the first map value.

59. The system of claim 58 wherein the filter accepts a plurality of image pixel sets, in a plurality of frames and generates FV by:

randomly selecting a first collection of pixel positions with respect to the test pixel;

using pixels in the first collection to calculate FV for each test pixel in every image pixel set, in every frame.

60. The system of claim 58 wherein the filter accepts a plurality of image pixel sets, in a plurality of frames and generates FV by:

randomly selecting a first collection of pixel positions with respect to the test pixel in a first image pixel set in a current frame;

using pixels in the first collection to calculate FV for each test pixel in every image pixel set in the current frame;

randomly reselecting a second collection of pixel positions in an image pixel set in a frame subsequent to the current frame; and,

using pixels in the second collection to calculate FV for each test pixel in every image pixel set in the subsequent frame.

61. The system of claim 57 wherein the filter selects predetermined pixel positions, with respect to the test pixel, from the second group to calculate FV, if they are equal to the first map value.

62. The system of claim 61 wherein the filter accepts a plurality of image pixel sets in a plurality of frames and selects the pixels in the predetermined pixel positions to calculate FV for each test pixel in every image pixel set, in every frame.

63. The system of claim 61 wherein the filter accepts a plurality of image pixel sets in a plurality of frames and generates FV by:

selecting the pixels in a predetermined first collection of pixel positions to calculate FV for each test pixel in every image pixel set in a current frame; and,

selecting the pixels in a predetermined second collection of pixel positions to calculate FV for each test pixel in every image pixel set in a frame subsequent to the current frame.

64. The system of claim 61 wherein the filter generates FV by:

selecting the pixels in a predetermined first collection of pixel positions to calculate FV for test pixels in a first image pixel set; and,

selecting the pixels in a predetermined second collection of pixel positions to calculate FV for test pixels a second image pixel set.

65. The system of claim 54 wherein the filter uses pixels from the second group to calculate FV, if they are equal to a first map value, by:

selectively weighting second group pixel values;

summing the weighted values; and,

averaging.

66. The system of claim 65 wherein the filter adds the test pixel to the second group of pixels.

67. The system of claim 65 wherein the filter selectively weights in response to number of pixels in the second group.

68. The system of claim 54 wherein the filter generates FV by:

calculating nV = sum of second group pixel values for pixels having a map value of 0;

calculating nE = total number of pixels in the second group with a map value of 0;

if $nE = 1$, then $FV = (nV + P(i,j) + 1) >> 1$;

if $nE < 4$, then

$nV = nV + (4 - nE) * P(i,j)$; and,

$FV = (nV + 2) >> 2$;

if $nE < 8$, then

$$nV = nV + (8 - nE)*P(i,j); \text{ and,}$$

$$FV = (nV + 4) >> 3;$$

if $nE = 8$, then

$$nV = nV - P(i + 1, j + 1) + P(i,j); \text{ and,}$$

$$FV = (nV + 4) >> 3.$$

69. The system of claim 54 wherein the filter generates FV by:

calculating nV = sum of second group pixel values for pixels having a map value of 0;

calculating nE = total number pixels in the second group with a map value of 0;

if $nE = 1$, then $FV = (nV + P(i,j) + 1) >> 1$;

if $nE < 4$, then

$$nV = nV + (4 - nE)*P(i,j); \text{ and,}$$

$$FV = (nV) >> 2;$$

if $nE < 8$, then

$$nV = nV + (8 - nE)*P(i,j); \text{ and,}$$

$$FV = (nV) >> 3;$$

if $nE = 8$, then

$$nV = nV - P(i + 1, j + 1) + P(i,j); \text{ and,}$$

$$FV = (nV) >> 3.$$

70. The system of claim 54 further comprising:

an accessible memory including a lookup table (LUT) with pre-calculated values;

wherein the filter generates a FV in response accessing the LUT.

71. The system of claim 70 wherein the LUT is indexed by nE values: and,

wherein the filter calculating nE = the total number of pixels in the second group with the first map value, and uses nE to access the LUT.

72. The system of claim 71 wherein the LUT includes a value for each nE indicating the number of times the test pixel P(i,j) is added.

73. The system of claim 71 loading the LUT includes a value for each nE indicating the number of times the result is right shifted.

74. The system of claim 71 wherein the LUT includes a value for each nE indicating if a pixel value from second group of pixels is subtracted.